SITARA SYSTEMS · TECHNICAL REPORT

Designing NFC Interactions for the Public:

Best Practices for Instructing First-Time Users of Smart Objects

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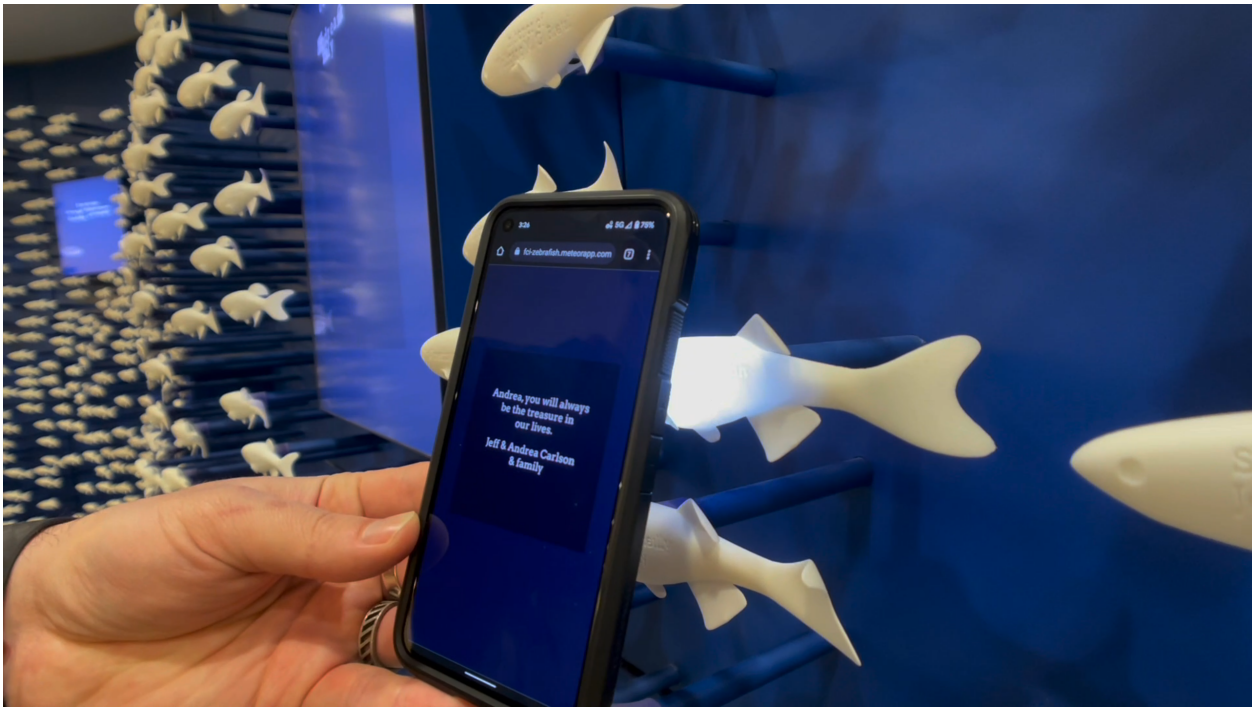

Figure 1. A visitor uses near-field communication (NFC) to interact with a smart object embedded in a permanent artwork at Dana-Farber Cancer Institute. The guidance in this document comes from designing and studying installations like this one, where the object itself can carry no visible tag, code, or label. (© Author)

Abstract

Near-field communication (NFC) lets a smartphone act on a physical object through a brief, contactless gesture, which makes it valuable for embedding interactivity in public installations where a visible reader or a printed code would be intrusive. In practice, people who are not told they are using NFC often cannot complete the interaction at all.

This report gathers what is known about instructing non-expert users of NFC smart objects. It draws on two sources: the published HCI literature on NFC interaction, discoverability, and the design theory of affordances and feedforward; and a two-round formative field study we ran on a permanent installation, in

which no participant could trigger the interaction under written instructions alone, while a revised design that *showed* the gesture as motion took four of five to independent success.

We consolidate both into a short set of best practices: avoid payment- and scan-laden language, show the gesture rather than name the technology, supply on screen the signifier the object cannot carry, guide the two-axis search for the phone's reader, and confirm success explicitly. The report is aimed at designers and studios building public-facing NFC interactions, and at teams weighing NFC against alternatives such as QR codes.

Keywords: near-field communication; NFC; usability; smart objects; feedforward; signifiers; motion graphics; interaction design; public installations

1 Introduction

Near-field communication (NFC) enables contactless interaction between devices at very short range. It underpins mobile payment, transit ticketing, access control, and home automation, and because it needs no cabling, no app, and no line of sight, it is well suited to smart objects that respond when a phone is brought near them. For public installations in particular—museums, exhibits, artworks, experience centers—NFC has a property no other technology matches: it can disappear entirely into an object, adding a digital layer without a visible reader, screen, or printed code on the object itself.

That same invisibility is the problem. When nothing on the object signals that it is interactive, and when the user does not already know what NFC is, the interaction frequently fails before it begins. This is not a hardware limitation; modern tags read quickly and reliably. It is a problem of *instruction*: how a design tells a first-time user that an interaction is available, and how to perform it.

This report is a practical answer to that question, assembled for designers building public-facing NFC interactions. It rests on two bodies of evidence. The first is the published HCI literature, which has studied NFC discoverability and positioning for over a decade and supplies the design theory—affordances, signifiers, and feedforward—that explains why some instructions work and others do not. The second is our own field study of a permanent NFC installation, which tested instruction designs directly with members of the public and produced a clear, if narrow, result. Section 2 lays out the design problem and what research knows about it; Section 3 presents our field evidence; Section 4 consolidates both into best practices; Section 5 states the limits of what we can currently claim.

2 The Design Problem, and What Research Knows About It

Five difficulties recur when non-expert users meet an NFC interaction. Each has been observed in the research literature and each appeared in our own study; we group them here with the work that bears on them.

Figure 2. A subset of the NFC marks in use today. From left to right: the original NFC Forum logo (the "N-Mark"); the EMVCo Contactless Symbol, designed for payments; the Seritag NFC logo; the Material Design (Android) NFC icon; and the NFC Forum Wayfinding Mark. With no single standard, no mark yet functions as a reliable signifier.

2.1 No signifier: making an invisible interaction perceptible

Design theory draws a sharp line between an *affordance*—what an object lets you do—and a *signifier*—the perceptible cue that tells a person the action is possible and how to take it (Norman, 2013). An embedded NFC tag is almost pure affordance with no signifier: the object can be acted on, but nothing about it says so. Compounding this, NFC has no settled iconography to borrow as a signifier—as many as eight distinct marks are in current use (Figure 2)—so even a deliberately placed symbol carries little shared meaning (Hang et al., 2010). Hang et al. (2010) showed that the visual design of physical NFC interfaces materially changes whether users understand where and how to present their phone; discoverability, not reliability, is what limits these interfaces in the field (Spinsante and Gambi, 2015).

The design response is *feedforward*: information that communicates what will happen and how to act *before* the user acts, as distinct from feedback, which arrives after (Wensveen et al., 2004). Vermeulen et al. (2013) frame feedforward as the bridge across Norman's "gulf of execution"—the gap between wanting to do something and knowing how. Where the object cannot carry a signifier, a companion screen can supply feedforward in its place. Much of this report is about doing that well.

2.2 Positioning: the hardest physical step

Even a user who understands the goal must still bring the phone's reader within a few centimeters of the tag—and there is no standard location for the reader across phones. Hardy et al. (2010) compared NFC interaction techniques (touching, pointing, scanning) and found the physical act of aligning phone and tag to be a genuine bottleneck, not a formality. The installed base makes this worse: NFC support is uneven across the phones the public actually carries, with reading disabled by default on some models and absent on others (Kerr and Schmitt, 2019). A design cannot assume a known reader position, or even that a given visitor's phone will read a tag without configuration; it has to guide an exploratory search.

2.3 Semantic collisions: payment and QR codes

For most people, NFC *is* contactless payment—by a wide margin the context in which they have met it (Zignani and Sealy, 2022). That dominant association is a liability everywhere else: an NFC prompt reads as a financial transaction, and users hesitate to bring a phone near an unfa-

miliar object for fear of being charged. The available vocabulary reinforces the confusion. “Tap” and “contactless” evoke payment; “scan” evokes a QR code and sends users to their camera app. Instruction language has to be chosen against these priors, not merely for literal accuracy.

2.4 Precedent: NFC in cultural settings, and how public artworks differ

NFC has an established track record in exactly the settings this report targets. Blöckner et al. (2009), in “Please touch the exhibits!”, deployed NFC in a museum so visitors could explore exhibits by touching tags with a phone, and reported that first-time users still needed guidance to grasp the interaction. Our setting pushes one step past theirs in a way that matters: a museum can affix a visible tag or label to an exhibit, but a permanent artwork made of engraved, personal objects can carry no visible tag, code, or label at all. With no possible signifier on the object, the entire communicative burden falls on the screen—which is why the wording and the motion graphic, studied below, carry so much weight.

3 Field Evidence: A Permanent NFC Installation

The guidance above is not only a reading of the literature; we tested it. This section reports the field study behind it.

3.1 Setting and motivation

In 2012 we built an interactive sculpture whose 3D-printed elements responded to touch through embedded capacitive sensors, installed at a cancer research and care institute. Each element carries an engraved message from an individual, and visitors triggered a personalized response by touching it. In 2020, the institution asked us to remove touch interaction as a COVID-19 precaution. QR codes were the obvious contactless substitute, but adding a printed code to each object would have marred surfaces meant to stay personal and permanent. NFC let us restore a contactless interaction without changing how the objects looked—provided we could instruct the public to use it. We began from the most detailed public guidance available, the NFC Forum’s N-Mark usage guidelines (Forum, 2021) and Apple’s Human Interface Guidelines for NFC (Apple, 2023), both of which advise against implying physical contact (“tap”, “touch”), against naming the technology, and in favor of short, concrete instructions.

3.2 Method

We ran a qualitative, formative usability study to learn which on-screen instructions let a first-time user complete the interaction, and where users get stuck. We recruited ten participants through social media and local community mailing lists, sampling for a range of ages and a spread of phone models approximating the U.S. installed base (Kerr and Schmitt, 2019), and excluding self-described “techies” and “early adopters” whose fluency would have masked the difficulties we wanted to surface. Small per-iteration samples are standard for formative testing, where a handful of users surfaces most of a design’s interface problems and effort is better spent iterating

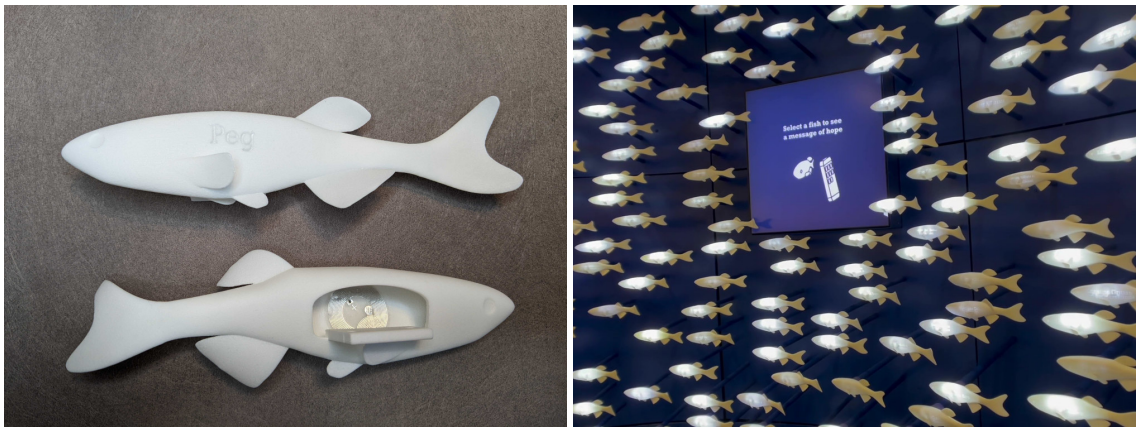

Figure 3. The smart object: a 3D-printed fish (left) that is one element of a larger art sculpture (right). The full sculpture contains 477 such objects, each of which displays a personalized message when its NFC tag is read. (© Author)

than on one large panel (Nielsen and Landauer, 1993; Nielsen, 2000). We split the ten into two groups of five: the first evaluated an initial design, and we folded their results into a revision tested with the second. No one took part in both rounds.

Each session followed a think-aloud protocol (Lewis, 1982; Lewis and Rieman, 2006): participants narrated their thoughts while attempting a single task—scan the tag embedded in a 3D-printed object, using only the on-screen instructions to cue the interaction—on a tabletop prototype of the installation (a central display and five objects; Figure 4). Sessions were structured as a five-act interview (Knapp et al., 2016), recorded on audio and video with an observer taking notes; recordings, notes, and transcripts were coded and analyzed thematically (Banfield et al., 2015).

3.3 Round one: written instructions alone failed

We tested five instruction sets, including a null condition with no text (Figure 4); the no-text condition was shown first, the four text conditions in random order. No participant completed the interaction without facilitator intervention under any instruction set (Table 1). The failures clustered into four patterns (Table 2): reading “contactless scan” as a **payment**; treating “scan a fish” as a **QR code** and opening the camera; **mirroring the on-screen image** by pressing the phone against the instruction screen rather than the object; and, even once the goal was understood, **difficulty positioning** the phone against the tag. Two problems underlay all four: the wording primed the wrong technology, and aligning the phone with the tag was hard.

3.4 Round two: showing the gesture worked

The revised design applied the round-one lessons: succinct, technology-neutral wording to avoid the payment and QR collisions, and a motion graphic that guided placement along two axes rather than describing it in words. It demonstrated the interaction in two steps—bring the phone close to the object, then move it slowly up and down to align the reader with the tag (Figure 5). Under the same protocol, four of five participants completed the interaction without any facilitator

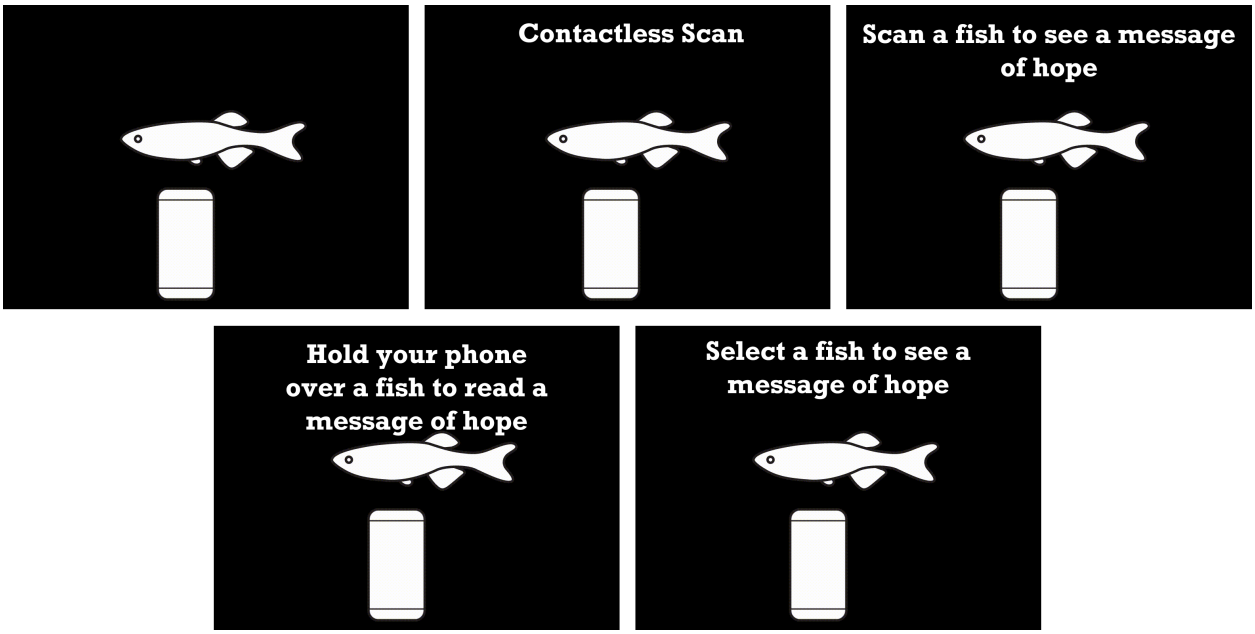

Figure 4. The five instruction sets used in the first round, each pairing written text with a motion graphic of a phone being lowered toward the fish. (© Author)

Instructions	P1	P2	P3	P4	P5
No text	✗	✗	✗	✗	✗
“Contactless scan”	✗	✗	✗	✗	✗
“Scan a fish . . .”	✗	✗	✗	✗	✗
“Hold your phone over a fish . . .”	✗	✗	✗	✗	✗
“Select a fish . . .”	✗	✗	✗	✗	✗

Table 1. Whether each participant (P) completed the interaction without any facilitator intervention, by instruction set. A ✓ marks an unaided success; a ✗ marks a participant who did not succeed without intervention.

intervention—against none in the first round—and the same four found the correct placement on their own (Table 3). One participant (P6) still required help. Given the sample the result is directional rather than conclusive, but the contrast with round one is large, and it points in the direction the design theory predicts: the motion graphic acts as feedforward, standing in for the signifier the object cannot provide.

4 Best Practices

The following consolidate the literature and our field evidence into guidance a designer can apply directly. Each practice notes the reasoning and its sources.

Observation	P1	P2	P3	P4	P5
Confused “Contactless Scan” with payment technology	✓	✓	✓	✗	✓
Confused “Scan a fish . . .” with QR Codes	✓	✓	✗	✗	✓
Attempted to place phone directly on instruction screen	✓	✓	✓	✗	✓
Completed task with facilitator intervention	✓	✓	✓	N/A	✓
Difficulty identifying appropriate distance from NFC Tag	✓	✗	✓	✗	✓
Difficulty positioning NFC Reader on their mobile device	✓	✓	✓	✗	✓

Table 2. Whether each observation occurred for each participant. A ✓ marks the observation as present; a ✗ marks it as absent.

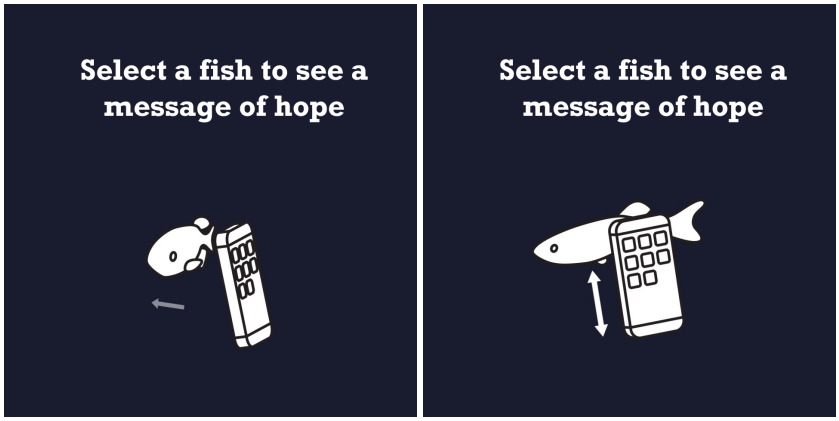

Figure 5. Stills from the improved motion graphic, showing the interaction in two steps: move the phone close to the object (left), then find the reader by moving the phone slowly and vertically near the tag (right). (© Author)

The most reliable instruction we found showed the gesture as motion, and never named the technology.

1. **Show the action; do not name the technology.** Users do not need to know what NFC is, and naming it adds a term to learn. Demonstrate the gesture instead. This matches both major industry guidelines (Forum, 2021; Apple, 2023) and our finding that unfamiliar terminology consistently derailed participants.

Observation	P6	P7	P8	P9	P10
Completed task without facilitator intervention	✗	✓	✓	✓	✓
Identified correct device placement	✗	✓	✓	✓	✓
Completed task with facilitator intervention	✓	✓	✓	✓	✓

Table 3. Observations for each participant using the improved prototype. A ✓ marks the observation as present; a ✗ marks it as absent.

2. **Choose verbs that do not collide with payment or scanning.** "Tap" and "contactless" read as payment; "scan" sends users to their camera for a QR code (Zignani and Sealy, 2022). Prefer neutral, physical phrasing such as "hold your phone near" or "move your phone to"—and test it, since these priors are strong and local.

3. **Supply on screen the signifier the object cannot carry.** An embedded tag offers an affordance but no signifier (Norman, 2013), and NFC's iconography is too fragmented to serve as one (Hang et al., 2010). When the object cannot show that it is interactive, the companion screen must—through feedforward that communicates the action before it is taken (Wensveen et al., 2004; Vermeulen et al., 2013).

4. **Demonstrate the gesture as motion, not as text.** A moving demonstration outperformed every written instruction we tested. Show the two motions that matter: approaching the object, and searching along the phone's surface for the reader. Static or single-axis instructions leave users stuck at exactly the step that is hardest (Hardy et al., 2010).

5. **Guide an exploratory search for the reader; design for device variety.** There is no standard reader location, and support varies across the phones the public carries (Kerr and Schmitt, 2019; Hardy et al., 2010). Encourage users to move the phone slowly across its upper half until the interaction triggers, rather than implying a single correct spot.

6. **Confirm success explicitly.** Sparse feedback leaves users unsure whether anything happened (Spinsante and Gambi, 2015). Pair feedforward with clear feedback—a visible or haptic confirmation the moment a tag is read—so the interaction has an unambiguous end (Wensveen et al., 2004).

7. **Avoid over-literal instructions.** Highly literal phrasing ("hold your phone over the fish") was mirrored against the on-screen image rather than the physical object. Convey intent and motion, not a literal pose to copy.

5 Limitations and Open Problems

Our field evidence is formative: ten participants across two single-session rounds, one object type, and one installation. We report qualitative patterns and unaided-completion counts, not calibrated success rates, and the improved design changed both wording and graphic at once, so the study cannot fully separate their contributions; the null-text condition was also always shown first. Small per-round samples are right for surfacing interface problems (Nielsen and Landauer, 1993; Nielsen, 2000) but not for estimating population success rates, and the revision was validated with a single group of five. Treat the best practices as well-grounded design defaults, corroborated by prior research, rather than as quantified guarantees.

Two problems remain open for the field. Reader placement is still unstandardized across devices, so positioning guidance is a workaround for a hardware inconsistency, not a fix for it. And platform affordances are shifting—system-level background tag reading and lightweight on-demand apps lower some barriers—but they do not remove the core problem: a silent object still has to tell a first-time user that it is interactive. Until it can, the instruction is the interface.

6 Conclusion

NFC's great advantage for public installations—that it can vanish into an object—is also the reason its interactions fail for first-time users: an invisible interaction has no signifier. The published research and our own field study agree on the remedy. Move the signifier onto the screen and deliver it as feedforward; show the gesture as motion instead of naming the technology; choose language that dodges the payment and QR associations; and guide the search for the phone's reader. In our study these moves took participants from no unaided successes to four of five. They will not make every NFC interaction effortless, but they reliably close the gap between an object that can be used and a visitor who knows how.

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